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# AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology and Medical Climatology.

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*NOTE.— This Journal offers prizes for the best studies of tornadoes. Competition closes July 1st, 1889. For particulars send to Mr. Harrington, at Ann Arbor, for special circular.*

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M. W. HARRINGTON,
*Director of the Astronomical Observatory, Ann Arbor, Michigan,*
A. LAWRENCE ROTCH,
*Proprietor of the Blue Hill Meteorological Observatory, Massachusetts,*
W. J. HERDMAN, PH. B., M. D,
*University of Michigan.*
Editors.
K. KITTREDGE, Manager.

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THE AMERICAN
# METEOROLOGICAL JOURNAL.

VOL. VI. ANN ARBOR, JUNE, 1889. NO. 2.

## ORIGINAL ARTICLES.

### THE ORGANIZATION OF THE METEOROLOGICAL SERVICE IN SOME OF THE PRINCIPAL COUNTRIES OF EUROPE.

BY A. LAWRENCE ROTCH,
Member of the German Meteorological Society, and Fellow of the Royal (London) Meteorological Society.

#### BELGIUM.

*History.*—The Royal Observatory of Brussels was founded in 1826. M. A. Quetelet was appointed director and held the position until his death in 1874. Besides an astronomical department it has included from its establishment a meteorological and magnetic one, and M. Quetelet early undertook observations of earth temperatures at various depths, and was the first to observe regularly the temperature of the surface layers. He also studied atmospheric electricity at different heights and under various conditions, and instituted phenological observations which relate to the animal and vegetable kingdoms. During the half century of M. Quetelet's work, science had made great progress and the instrumental equipment of the observatory had become insufficient and antiquated. In 1876 the meteorological and magnetic department was reorganized at a cost of 100,000 francs, and M. J. C. Houzeau was appointed director of the Observatory. He was succeeded in 1885 by M. F. Folie, the present incumbent.

The organization of the present net-work of stations was effected in 1876, and it has been extended each year since. The Observatory had for many years lent instruments to observers, but there was no regular inspection of the stations, return of the reports nor publication of the results. Some were, however, published in the Memoirs of the Belgian Academy. The service for Weather Telegraphy is also of recent date, the daily *Bulletin* having been issued since 1877.

*Organization.*— The meteorological system of Belgium is under the superintendence of the Royal Observatory of Brussels, where all observations are centralized, reduced and published. There are three stations of the first order with registering instruments, viz: Brussels (Royal Observatory), Liege (University) and Ostend, but the observatory of the University of Liege for astronomical and meteorological researches is quite independent of the Brussels Observatory. There are 50 stations of the second order which observe twice daily the pressure, temperature, wind, clouds and precipitation; 65 third order stations which observe the amount of precipitation and twice daily the cloudiness, besides about 120 rain stations established by the *Administration des Ponts et Chaussées* whose schedules are published by the Observatory; and 150 stations, including some of the above, which send thunderstorm reports to the Observatory. The observers are volunteers, and are generally not paid. They are professors, clergymen, engineers, agriculturists, manufacturers, etc.

THE ROYAL OBSERVATORY OF BRUSSELS.

The Observatory is situated on high ground in the north-east quarter of Brussels, but suffers the meteorological disadvantage that the prevailing south-west winds come over the city and are thus warmed, while the magnetic observations are disturbed by the iron railings and by the passing of vehicles on three sides of the building. The Observatory includes two distinct departments for astronomy and meteorology, including also terrestrial magnetism. The meteorological and magnetic instruments are chiefly in the east wing of the building and in the garden.

*The Meteorological and Magnetic Instruments.*—The normal barometers are of the Fortin type, one of them constructed by Ernst, with their cisterns 57 m. above sea-level. They are located in a room on the ground-floor, opening to the north, in which fire is never made; but the photographic registering barometer of Ronalds is in a partly underground room. In this apparatus the column of mercury cuts off luminous rays, concentrated by a lens, falling on sensitized paper moved by the revolution of a vertical cylinder. The expansion of the mercury by heat is counteracted by the dilatation of the metallic bar having the slit through which the light passes.

The normal thermometers are in isolated shelters on the north and south sides of the Observatory. Stevenson's screen was formerly employed, but Renou's screens, with double roof and without louvres, have been erected for comparisons of the two systems. In the garden on the north side of the Observatory, is a large louvred screen with double roof. Screens on the east and west sides and a canvas cover further protect it from the sun's rays. At a height of 1.30 m. above the ground are placed the usual thermometers and two hair hygrometers. On the south side of the Observatory is a similar screen and two of the Renou type. Maximum and minimum thermometers placed on the ground give the highest and lowest temperatures there, the minimum temperatures being generally some tenths of a degree lower than in the screens. The earth thermometers, the Campbell-Stokes sunshine recorder and the chemical rain register of a system analogous to that of Hervé-Mangon are no longer in use. The wet and dry bulb thermometers for the registering instruments are exposed in wall screens with open bottoms and ventilated tops. The photographic register is of the pattern used at the Kew Observatory near London. The tubes of the thermometers are bent twice at right angles, so that they may penetrate into a room. In the upper part of the column of mercury is an air bubble, and the light from a gas jet, reflected by a mirror, passes through the bubble and forms an image on a cylinder covered with sensitized paper and making a revolution on its axis in twenty-four hours. The image of the

wet bulb thermometer is brought by a lens directly under that of the dry bulb, but in order to prevent their coincidence, it is set one degree too low.

The rain and snow gauges are placed together on a terrace south of the Observatory, with their receivers about 1.50 m. above the ground. The rain gauge has the form of an inverted rectangular pyramid, its open base being 1 dcm. by 2 dcm. The snow gauge consists of two hollow truncated pyramids, joined together at their bases, to prevent the snow from blowing out. There is the Babinet gauge which is used at the Belgian and French stations. The gauge for the meteorograph receives water upon a tilting bucket which makes an electric circuit for each gramme, or 0.1 mm., of rain. Snow is melted by passing the vapor of methyl alcohol through a coil of tubing surrounding the gauge. On the roof of the west tower is a gauge showing the amount of rain for each wind direction. A pipe leads from the receiving vessel, which is 5 dcm. square, over a cylinder having eight radial receptacles, representing the eight wind directions, which cylinder is connected by an endless chain with the spindle of the wind vane. The evaporimeters expose a surface of water 2 dcm. square, and 9 cm. deep to the sun, wind and rain. One is attached to the tower railing, the other to the terrace railing, and near each is a rain gauge, with the same shape and size of receiver, in order to estimate the precipitation which falls into the evaporimeter.

The anemometers are placed on the west tower of the Observatory. Prior to 1878 an Osler anemometer giving the force of the wind in kilos per square foot was employed. The present instrument was constructed by Adie and has Robinson cups above a wind-mill vane. Each of these motors actuates a metallic spiral which transfers its trace to paper on a cylinder with a parallel axis. The velocity is expressed in km. per hour and the direction to eight points of the compass. Atmospheric electricity which was for thirty years observed with the Peltier electrometer is now registered with the apparatus constructed by J. White, of Glasgow, on Sir William Thomson's principle. The electricity is collected by water dropping outside the building

from a long tube connected with an insulated metal reservoir. It is measured by an electrometer whose needle has a mirror which reflects the light from a gas jet on sensitized paper unrolled in a box during twenty-four hours.

Besides the photographic registers there is the meteorograph invented by M. F. Van Rysselberghe and constructed by Th. Schubart, which was installed in 1879, and continues to operate satisfactorily. The distinguishing feature of this instrument is that it engraves the values on metal plates from which copies can be printed. The registration of the following data is effected in this order: dry bulb thermometer, wet bulb thermometer, precipitation, direction of wind, height of barometer and velocity of wind. The values of these elements, engraved mechanically on a sheet of zinc wrapped around a vertical cylinder, are represented by horizontal lines whose lengths are proportional to the numbers to be recorded. To accomplish this the cylinder, liberated from a catch each ten minutes by means of an electric connection with a clock, makes a revolution, during which the graver, actuated by an electro-magnet, traces a line whose commencement is regulated by the controlling instrument. The indications of the various instruments are recorded successively, after which the graver descends a line, the lines being further separated every two hours. The bulbs of the wet and dry thermometers are placed outside the window, but the tubes project into the room, where they are vertical and open. Every ten minutes fine metallic wires descend into the tubes, and the graver acts the instant the wire touches the column of mercury, and thereby establishes an electric circuit. A siphon barometer permits the contact to be made in its short leg. For the wind direction the spindle of the vane has eight sectors corresponding to the principal points of the compass. The wind velocity is measured by the action of the Robinson cups upon a cam. The tilting of the rain-gauge bucket by closing an electric circuit registers in a somewhat similar way. This is the principle of the apparatus, but in practice, two currents in opposite directions and a relay are used. The accuracy of registration is said to be within half a mm. for the barometer and within some

tenths of a degree for the thermometers. The cost of the apparatus was 4,500 francs as compared with 10,000 francs for the Theorell meteograph, and 16,000 francs for that of Secchi. The cost of operating, including printing, but exclusive of the battery power, is only about 100 francs a year. The zinc plate is changed each five days, and ten copies are printed from it. The registering apparatus may be at any distance from the transmitting instruments, as first suggested by Buys Ballot, and this was actually done by recording at Brussels the indications of instruments placed at Ostend. Complete eye observations are made at Brussels at 8, 9 and 10 A. M., 12, 12.17, 1, 2, 3, 4 and 9 P. M.

The magnetic instruments for relative measurements are in a south-east room of the ground floor of the Observatory. A unifilar magnetometer of Gauss, serves to measure the declination. The needle carries a mirror in which the image of the divisions of a scale is read by a telescope mounted on an isolated pier. Since the establishment of the Observatory the magnetic needle has approached the true north by more than five degrees; its variation is now about 15° W. The sudden fluctuations, or perturbations, of the needle are noted in the daily Weather *Bulletin* whenever they reach a certain amplitude. A bifilar magnetometer of Gauss, constructed by Grubb, of Dublin, measures the horizontal intensity by the use of the telescope before mentioned. A Lloyd balance, constructed likewise by Grubb, which is also mounted on an independent pier, gives the vertical component of the magnetic force by observation with two microscopes, one of which is movable. These instruments date nearly from the foundation of the Observatory. For five years they were observed each two hours, night and day, but are now read only four times a day, at 9 A. M., 12, 3 and 9 P. M. The registering magnetic instruments are below the variation instruments in the half-underground room with the photographic barograph. They are similar in principle to the variation instruments, but register photographically their indications by the Kew system upon three cylinders covered with sensitized paper. The light reflected from mirrors attached to the middle of the instruments

falls upon these cylinders, and in consequence of this rotation produces continuous traces representing the variations of these elements. The apparatus was constructed by Adie in 1878. Absolute measurements of declination are made once a month in a pavillion in the garden, but on account of local disturbances these are not now accurate. Absolute measurements are also made regularly at the new Observatory at Uccle.

*Weather Telegraphy.*—The Observatory is the central station for weather telegraphy in Belgium and receives daily reports from about fifty stations, mostly for the morning but some for the noon observations. These include four Belgian stations at 8 A. M. and at noon, four Dutch stations from Utrecht, nine English stations, ten German from Hamburg, eleven French from Paris, four Russian and Austrian, and five Scandinavian stations from Hamburg, all transmitted in the international cipher code. From these data the *Bulletin Météorologique* is prepared. This was established in 1876 and has several times changed its form, the last time in 1886. In its present form the *Bulletin* is a folio sheet containing on the inside pages two blue lithographed maps of Europe, one having in black the isobars for each 5 mm. and the winds, the other the isotherms for each 5° C. (dotted or full according as temperature is below or above 0°) and the weather represented by conventional symbols. Underneath the maps are the 8 A. M. and noon reports from five Belgian stations, the curves of the pressure, temperature and humidity, and hourly data for wind velocity and direction at Brussels, besides the normal and extreme temperatures and the declination of the magnetic needle. A summary of the atmospheric conditions for 8 A. M. over Europe is given, with predictions for the following day for all Belgium. These predictions have recently been recommenced and the percentage of their verification is about 80. The *Bulletin* is issued about 4:30 P. M. and reaches most parts of Belgium the same evening. Its circulation is about 400 and its subscription price only 15.60 francs a year. The newspapers publish the weather conditions and the predictions — in Brussels the same evening, in the provinces the next evening — but none reproduce the charts.

Warnings are sent from the London Meteorological Office whenever the south cone is hoisted, and the New York *Herald* storm warnings are received. Daily telegrams are sent from Brussels to Paris, London and Hamburg, and to the Belgian seaports and fishing stations, where they are posted, but there is no system of storm signals. Notice is sent to the Administration of Mines when there is a barometric fall exceeding 1 mm. per hour, that precautions may be taken in the mines against the outflow of gas.

*Staff, Budget and Publications.*—The Observatory is managed by a committee appointed by the Minister of the Interior. The staff consists of a director, M. F. Folie; a meteorologist in charge of the service, M. C. Hooreman; an inspector, M. A. Lancaster; a meteorologist, M. J. Vincent; a joint meteorologist and four assistant meteorologists. The three meteorologists are nominated by the King, the other officials by the Minister of the Interior. The director superintends the general work of the meteorological department, undertakes the correspondence with the government and with foreign countries. Once a month he assembles all the meteorological staff in his office in order to discuss quesions relating especially to the service. It should be observed that the Observatory comprises two distinct departments, astronomy and meteorology, both entrusted to the same director. All the staff take part in the observations, but the joint meteorologist undertakes the greater part of them; the whole staff also takes part in the reduction of the observations. The meteorologist in charge of the service and one of the assistant meteorologists have principally the charge of the self registering instruments. The inspection of the meteorological stations and the correspondence with the stations are undertaken by the inspector, who is also the librarian and the secretary of the Observatory. The discussion of the thunder storm observations is also done by him. The daily weather report is drawn up by an assistant meteorologist.

The salaries paid by the government are as follows: Director, 8,500 francs; meteorologist, minimum 4,000 francs, maximum 6,000 francs; joint meteorologist minimum 2,500 francs, maxi-

mum 3,500; assistants, minimum 1,200, maximum 2,400. The director has free apartments in the Observatory. The salaries of the meteorological staff aggregate 30,000 francs, and with the other current expenses bring the total budget up to about 50,000 francs yearly. The postal and telegraphic service is free.

Besides the *Bulletin Météorologique* the following meteorological publications are issued by the Observatory: *Annales*, of which the first series was published from 1834 to 1877. They contain, besides the work of M. A. Quetelet, on the Belgian climate and the physics of the globe, astronomical and meteorological observations made at the Observatory up to 1872 for astronomy and until 1875 for meteorology. The second series is divided into *Annales Astronomiques* and *Annales Météorologiques*, of which three quarto volumes have appeared. These contain the complete observations at Brussels for every two hours, the monthly *résumés* of the stations of the second and third order and the annual discussion of the thunder-storm observations by M. A. Lancaster. The meteorological observations taken at 8 A. M. and 1 P. M. at the four international stations of Belgium and the Netherlands from 1877 to 1884 were published in co-operation with the Meteorological Institute of Utrecht. The *Annuaire*, which dates from 1833, is a publication referring to the whole of the Observatory and not to the Meteorological Service only. It contains a review of the climate of Belgium during the preceding year by M. Lancaster, which is also printed separately. Since January, 1887, a *Bulletin Mensuel* has been issued containing the observations of temperature, humidity, cloudiness, wind, days of snow, hail, etc., for about 50 climatological stations and precipitation and days on which it fell at more than 230 stations. About 600 copies of the publications are distributed at home and abroad.

THE NEW OBSERVATORY AT UCCLE.

On account of the unfavorable situation of the Brussels Observatory for meteorological, magnetic and astronomical work, a new observatory has been established on a plateau with an admirable exposure 4 km. south of the city. Two dwellings for the director and assistants with offices and laboratories are

completed. There are isolated pavilions for the magnetic and meteorological apparatus, and a one-story building with a roof terrace for spectroscopic work. The cost of the buildings and grounds has been 2,500,000 francs. A large enclosed field serves for the exposure of the rain and snow gauges (the latter with Nipher screens), thermometer screens of the Stevenson pattern, earth thermometers, a Campbell-Stokes sunshine recorder, etc. One of the meteorological pavilions will contain the Van Rysselberghe meteorograph and the Ronalds photographic register, and on the roof are exposed anemographs constructed by Schubart, marking the velocity and force of the wind, its azimuth and inclination to the horizon, with the registering rain-gauge of Bonino. The Richard instruments for registering the pressure, temperature and humidity of the air are also in use. Provisional observations have been made at Uccle since April, 1886, by M. Vincent. By comparison with the air temperature at Brussels it is hoped to deduce the corrections which are necessary to apply to the observations made in the city since 1833, to reduce them to those made in the country. Besides the thermometric observations, the humidity of the air, precipitation, wind, weather, ozone, transparency of the air, temperature and condition of the surface of the ground, sky colors at sunset, thunder-storms, etc., are regularly noted.

THE EQUIPMENT OF THE STATIONS AND THE METHODS OF OBSERVATION.

The stations of the second order are furnished with a barometer, maximum and minimum and wet and dry bulb thermometers and a rain-gauge. The stations of the third order have only a rain-gauge. The barometer is made by Baudin and costs only 35 francs. It has a siphon tube whose graduations are compensated for the change of level of the mercury in the short leg.

The thermometers made by Baudin are a psychrometer, a Negretti maximum and a Rutherford minimum on a Baudin frame exposed in a Stevenson screen. The rain-gauge is made by Schubart on Babinet's principle. The receiver has a diameter of 20 cm. and is placed 1.50 m. above the ground. The

gauge is surrounded by a cylinder which protects it from solar radiation and in winter contains night-lights to melt snow. The instruments are generally furnished by the Observatory, but some observers purchase them. They are compared and verified at Brussels before being sent to the observers. They are verified again when the stations are inspected yearly or every two years.

The observations are entered on printed schedules furnished by the Observatory. These schedules are sent to Brussels during the first days of each month, and the Observatory repays the cost of postage, if claimed. Observations are made twice a day, at 8 A. M. and 1 P. M. The instructions for the Belgian stations are those prepared by M. Lancaster, a second edition of which was issued in 1884, containing reduction tables.

Only the barometric observations at the international stations are reduced to sea-level, and for these special tables are furnished. The schedules for entering the observations at stations of the second order are single sheets, one being intended for the 8 A. M. data, the other for those at 1 P. M. At the top of each is placed the name of the station and observer. The days of the month are arranged vertically and the following headings are at the top of the columns for the 8 A. M. sheet:

Barometer: Attached thermometer, observed, reduced to 0°, reduced to sea-level.

Temperature: Maximum, minimum.

Psychrometer: Dry-bulb thermometer, wet-bulb, humidity.

Direction and force of wind: by clouds and vane (16 points and scale of 6).

Cloudiness, (0–10).

Form of clouds, (Howard's nomenclature).

Precipitation, (entered to preceding day).

Remarks.

At the bottom of the sheet are means of these columns with the following additional data: Absolute maximum and minimum temperatures and their dates; total precipitation; number of days with rain, snow, hail, thunder and fog; frequency of the upper and lower wind directions. The sheet for 1 P. M. is

similar, except that the columns for extreme temperatures and for precipitation are omitted, and in place of the general summary for the month, the meanings of the international symbols are given. The schedule for the third order stations is a single sheet with the name of the station and observer at the top and vertical columns headed:

Date.

Amount of precipitation, (at 8 A. M., referred to the preceding day).

Cloudiness at 8 A. M. and 1 P. M.

Remarks.

At the bottom of the sheet is a general summary of the month, with the total precipitation; maximum fall in one day, and date; number of days with snow, hail and fog. The sheets containing the original observations are retained by the observers, copies, in which are included the instrumental corrections, being sent to Brussels. Some observers at the second order stations publish abstracts of the observations in the local newspapers.

The systematic study of thunderstorms in Belgium was commenced at the Royal Observatory in 1877, but about 1878 a change was made from the French system hitherto followed. Instead of investigating the theoretical explanation of the phenomena, it was thought more useful to seek the relation of thunderstorms to atmospheric depressions and to determine for Belgium the consequences of the relation. Special schedules are furnished to observers, which should be returned to the Observatory at the commencement of each month. Each schedule contains the observations during a single storm, and has the following arrangement upon one side of a sheet: At the top is the name of the commune, the date of the storm, and the name of the observer. Then follows:

Hour of commencement of storm (first thunder).

Hour of greatest intensity.

Hour of end of storm (last thunder).

Point of horizon from which it came (8 points).

Point of horizon in which it disappeared.

Direction of clouds (8 points).

Velocity of clouds (0–6).

Direction of wind (8 points).

Force of wind (0–6).

Intensity and duration of rain.

Hail, its size and duration.

Lightning strokes authenticated.

Persons struck by lightning.

Communes over which storm passed.

Observations on the appearance of storm, the state of crops before and after the storm, and on the damage by wind, rain, hail or lightning.

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PUBLICATIONS OF THE SIGNAL OFFICE.—In a circular dated April 1st, 1889, General Greely says that he "finds that an erroneous opinion prevails with a large number of persons to the effect that the publications of the Signal Service can only be obtained through the personal intervention of intermediate parties."

Farther, in the words of the circular:

"It is the aim and desire of the Chief Signal Officer to distribute the publications at his disposal to such persons, corporations, and institutions as are entitled to them on account of their scientific pursuits, original investigations for educational purposes, or proposed application to agricultural, commercial, manufacturing, and other business transactions.

"The intervention or recommendation of a second party is unnecessary, except so far as to guarantee the standing and good faith of otherwise unknown parties. A simple application for what is wanted, with a brief statement as to the necessity for the same, addressed to the Chief Signal Officer, Washington, D. C., will receive prompt attention.

"If the publications cannot be furnished the applicant will be so informed."

TORNADOES IN MICHIGAN.

## STATE TORNADO CHARTS.—MICHIGAN.

By LIEUT. JNO. P. FINLEY, Signal Service, U. S. A.

TABLE I.—*Tornadoes in Michigan.*

Period of observation, 66 years, 1823–1888.
Total number of storms, 76.
Year of greatest frequency, 1886,—18 storms.
Average yearly frequency,—4 storms.
Year in past (10) ten years no report of storms,—1884.
Months of greatest frequency, May and September,—16 storms each.
Day of greatest frequency, September 16th,—11 storms.
Hour of greatest frequency, 5 to 6 P. M.
Months without storms, January, March and December.
Prevailing direction of storm movement, NE.
Region of maximum storm frequency, southeastern portion of the Lower Peninsula.

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of Michigan for a period of 66 years, from 1823 to 1888.*

| County. | Month and Day. | Year. | Time. | Direction. | Form of Cloud. | Width of Path in Feet. |
|---|---|---|---|---|---|---|
| Chippewa | Summer. | 1823 | | | | |
| Lenawee | June 12. | 1829 | Afternoon. | | | |
| Kalamazoo | | 1834 | Afternoon. | E. | | |
| Kalamazoo | October 18. | 1834 | | | | 165. |
| Kalamazoo | | 1850 | | SE. | | |
| Hillsdale | May —. | 1853 | | NE. | | |
| Branch | May —. | 1854 | 3:30 p. m | NE. | Funnel. | 1,320 to 2 640. |
| Washtenaw | May 6 | 1855 | 4:30 p. m. | E 10° S. | " | 330 to 700. |
| Lapeer | May 16. | 1855 | Afternoon. | | | |
| Allegan | July —. | 1862 | | | | |
| Kalamazoo | July —. | 1862 | | | | |
| Kalamazoo | August 3. | 1862 | 4:30 p. m. | NE. | | 165. |
| Clinton | June 19. | 1869 | 5:45 p. m. | E 20° N. | Funnel. | 840. |
| Ionia | May 15 | 1873 | | | | |
| Van Buren | June 2. | 1875 | 2 p. m. | | | |
| Ingham | June 4. | 1875 | | E 20° N. | | 250 to 600. |
| Wayne | June 27. | 1875 | 6 p. m. | NE. | Funnel. | 150 to 200. |
| Lenawee | February 11. | 1876 | | | | |
| Wayne | November 11. | 1876 | | | | |
| Wayne | August 31. | 1877 | Afternoon. | E. | Funnel. | |
| Isabella | September 20 | 1878 | " | NE. | Cone. | |
| Lapeer | July 11. | 1879 | " | | | |
| Tuscola | October 3. | 1879 | | NE. | | |
| Wayne | November 12 | 1879 | 5 p. m | NE. | | 500. |
| Kalamazoo | | 1880 | | NE. | | 660. |
| Eaton | April 18. | 1880 | Afternoon. | NE. | | 1,200 to 1 500. |
| Kalamazoo | May 8. | 1880 | 11 p. m. | NE. | Funnel. | |
| Lapeer | September 26 | 1880 | 2 p. m. | NE. | " | 300 to 500. |
| Hillsdale | July 12. | 1881 | 3:30 p. m. | NE. | | |
| Clare | September 22. | 1881 | Night. | E. | | |
| Menominee | October 8. | 1881 | Afternoon. | NE. | Funnel. | |
| Van Buren, Allegan and Barry | April —. | 1881 | | NE. | | |
| Barry, Eaton, Ingham and Oakland | April 5. | 1882 | 5:30 p. m. | E 5° N. | Funnel. | |
| Washtenaw | April 6. | 1882 | 6:30 p. m. | NE. | " | 200 to 1,000. |
| St. Clair | " | 1882 | Evening. | | | |
| Oakland | " | 1882 | 8 p. m. | N 18° E. | Funnel. | 495 to 1,320. |
| Ingham | " | 1882 | 7 p. m. | E 6° N. | " | 40 to 825. |
| | | | | | | 1,155. |

TABLE II.—*Continued.*

| County. | Month and Day. | Year. | Time. | Direction. | Form of Cloud. | Width of Path in Feet. |
|---|---|---|---|---|---|---|
| Bay and Midland | April 6. | 1882 | 5:15 p. m. | E. | Funnel. | 1,320. |
| Barry and Eaton | " | 1882 | 5:30 p. m. | NE. | " | 600. |
| Allegan and Kalamazoo | " | 1882 | 5 p. m. | NE. | " | 50 |
| St. Clair | June 8. | 1882 | ..... | NE. | " | 495 to 1 320. |
| Huron | June 18. | 1882 | 1:30 a. m. | NE. | " | 330. |
| Bay | " | 1882 | 11:30 p. m. | NE. | " | ..... |
| Wayne | May 10. | 1883 | 3:30 p. m. | NE. | Baloon. | ..... |
| St. Joseph | May 14. | 1883 | 2 p. m. | E 15° N. | Funnel. | 100 to 660. |
| St. Joseph | " | 1883 | 2:50 p. m. | ENE. | " | ..... |
| Jackson | July 22. | 1883 | ..... | E 10° N. | ..... | ..... |
| Eaton and Ingham | July 23 | 1883 | 12 m. | E 20° S. | Funnel. | 20 to 2,640. |
| Wayne | August 22 | 1883 | 5:30 p. m. | ENE. | " | ..... |
| Washtenaw | " | 1883 | 4:30 p. m. | ENE | " | ..... |
| Kalamazoo | May 31. | 1885 | 2 p. m. | E 10° N. | " | ..... |
| Allegan | July 8. | 1885 | 11:40 p. m. | NE. | " | 990 to 1,980. |
| Hillsdale and Lenawee | September 8. | 1885 | 5 p. m. | ENE. | " | 200 to 600. |
| Lenawee | April 25. | 1886 | 10 p. m. | NE. | " | 1,320. |
| Ingham | May 14. | 1886 | 4 p. m. | NE. | " | 1,320 to 2,640. |
| Jackson | May 25 | 1886 | 6:30 p. m. | NE | " | ..... |
| Lapeer | May 27. | 1886 | About 11 p. m. | Easterly. | ..... | 175 to 1,320. |
| Lapeer | " | 1886 | About 10 p. m. | NE. | ..... | 175 to 1,320. |
| Kalamazoo, Barry and Calhoun | August 1. | 1886 | 10 a. m. | NE. | ..... | ..... |
| Kalamazoo | September 16. | 1886 | About 1 p. m. | Easterly. | Funnel. | Narrow. |
| Eaton | " | 1886 | 12:30 p. m. | NE. | Whirlwind. | ..... |
| Kalamazoo | " | 1886 | About noon. | NE. | ..... | ..... |
| Clinton | " | 1886 | " | NE. | Funnel. | ..... |
| Clinton | " | 1886 | " | Easterly. | ..... | ..... |
| Livingston | " | 1886 | p. m. | NE. | Funnel. | ..... |
| Livingston | " | 1886 | 1 p. m. | NE. | ..... | ..... |
| Jackson | " | 1886 | About 1 p. m. | NE. | ..... | ..... |
| Cass | " | 1886 | 11:30 a. m. | N 30° E. | Funnel. | 660 to 1,320. |
| Calhoun | " | 1886 | " | NE. | " | 660 to 1,320. |
| Jackson | " | 1886 | About 1 p. m. | Easterly. | " | ..... |
| Lenawee | October 14. | 1886 | 2 p. m. | NNE. | " | ..... |
| Menominee | May 2. | 1887 | 3 p. m. | NE. | ..... | Narrow. |
| Lenawee | July 9. | 1887 | 2:30 p. m. | NE. | ..... | " |
| Lenawee | September 6. | 1887 | 4 p. m | SE. | Funnel. | " |
| Cass | May 11. | 1888 | 3:30 p. m. | NE. | ..... | ..... |
| Marquette | August 20. | 1888 | 2:30 p. m. | NE. | Funnel. | 1,320 to 2,640. |

TABLE III.—*Relative frequency of Tornadoes by months and days, for Michigan.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

| Month. | Day of Month. | No. of Days. | Total No. of Tornadoes per month. |
|---|---|---|---|
| February | 11, | 1 | 1 |
| April | 5, (6)$^{2}$, 18, 25 and (—), | 5 | 11 |
| May | 2, 6, 8, 10, 11, (14)$^{3}$, 15, 16, 25, (27)$^{2}$, 31, (—)$^{2}$, | 12 | 16 |
| June | 2, 4, 8, 12, (18)$^{2}$, 19 and 27, | 7 | 8 |
| July | 8, 9, 11, 12, 22, 23, (—)$^{2}$, | 7 | 8 |
| August | 1, 3, 20, (22)$^{2}$ and 31, | 5 | 6 |
| September | 6, 8, (16)$^{11}$, 20, 22 and 26, | 6 | 16 |
| October | 3, 8, 14 and 18, | 4 | 4 |
| November | 11 and 12, | 2 | 2 |
| (—) Blank | (—)$^{4}$ | 1 | 4 |
| Total | | 50 | 76 |

NOTE.—The blank (—) signifies date missing.

## A REVIEW OF SOME IMPORTANT TORNADO LITERATURE.

By Frank Waldo.

The editors having requested me to write out a short article on the subject of Tornadoes, it has occurred to me that an account of some of the existing Tornado Literature would be of educational value. The subject of Tornadoes, in its limited sense, is one particularly adapted for study by American meteorologists, because this phenomena is met with in its most fully developed state in our own country. In fact, the full-fledged Tornado is purely an American product, and many, perhaps most, of the professional meteorologists consider these most disastrous storms as an entirely separate class from the destructive storms of other lands; the nearest approach to them being the occasional mammoth spouts and whirlwinds of India.

The occurrence of this phenomenon in so many portions of the United States makes the study of it of great scientific and practical interest; and the fact that every person stands a chance of witnessing this display of nature's mighty power, makes us want to know what those persons who have studied into the matter have found out about it. It is the purpose of this paper to point out where the inquirer after knowledge can find the most important Tornado studies and to call attention to some particular points therein, rather than to give the complete results of those studies.

I would place the references under four classes, viz.:

I. Descriptions of Tornadoes.
II. The Older Theories of Tornadoes.
III. Tornado Studies.
IV. Modern Tornado Theories.

### I. *Descriptions of Tornadoes.*

As we have to look entirely to American litarature for descriptions of this phenomenon, we can scarcely hope to find much of value, from a scientific point of view, for the period preceding the establishment of Silliman's Journal. Before this time the newspapers offered about the only medium for publication of

observations of natural phenomena, and the small size of the papers would not allow of anything but a slight mention of any storm, however devastating may have been its effect. Finley mentions "Niles' American Register" and the "American Almanac" as early sources containing descriptions of Tornadoes, but whether files of old newspapers have been examined for such information as they may contain, we have not seen stated. However, these early scattered accounts would be of small value, as the unique character of the Tornado was not then known, and the most important points to be noted would hardly have been made the subject of record.

In Silliman's Journal, and especially for the period from about 1835–50, are many detailed and complete accounts of observed tornadic phenomena as reported by Loomis, Redfield, Stoddard, Hildreth, Hare, Olmsted and others. These reports furnished the basis of most of the older theories of Tornadoes, and it is important to understand about how much information they furnished. In Reye's work "Die Wirbelstürme" published February, 1872, is given a list of 31 Tornadoes in the period 1794–1857, and for these storms he gives the following data, systematically arranged:

1. Place. 2. Day and hour. 3. Temperature; Width of path. 4. The direction of path and its length. 5. Velocity of progression. 6. Local duration and total duration. 7. External form. 8. Motion within. 9. Substances transported (distances). 10. Remarks.

Loomis had previously (Silliman's Journal, Vol. 43) brought together the results of 21 tornadoes and deduced a number of laws which these phenomena seemed to follow. Reye has, however, (in "Wirbelstürme") given a more complete investigation, and we may accept his results as showing our knowledge of the subject up to 1872, or about the time of the establishment of the U. S. Signal Service Weather Bureau. The most important points noted by Reye are (given here numbered for convenience):

1. Usually accompanied by thunder and lightning. 2. Leeward roofs and surfaces burst outward, and the windward sub-

ject to greater pressure, (not confined to spiral motion). 3. High temperature at the beginning of storm. 4. Sultry before. 5. Greatest frequency between noon and 6 P. M. 6. Most frequent occurrence in the late spring—May and June months of greatest frequency. 7. Conical or funnel-shaped cloud with base uppermost. 8. Average width of path about 680 meters (2,270 feet); extreme breadth about a mile. 9. Average length of path about 42 miles. 10. Progressive velocity about 37 miles per hour. 11. Local duration usually from one-fourth to three-fourths of a minute, but frequeutly almost instantaneous. 12. The velocity of the wind very much greater than the progressive motion of the storm. 13. Inward and upward motion of air, but not always spiral-formed. 14. When a rotary motion has been found it is always opposite to the sun, (counter clockwise). 15. Nearly always the progressive motion is eastwardly, and is straight-lined or only slightly curved in its path. 16. The mean path is E. 13 N. 17. Sometimes several tornadoes are formed near each other (20 to 100 kilometers apart) and move in parallel paths. 18. The paths are often discontinuous. 19. In a broken country descending surfaces are swept with greater violence than ascending slopes.

While Reye lays great stress on observations of the wind as shown by the relative location of objects before and after the passage of a tornado, yet he thinks that many observations made, such as, feathers taken from the backs of fowls, are without scientific value.

## II. *Tornado Studies.*

With the entablishment of the Signal Service Weather Bureau, and consequently the greatly increased facilities for obtaining meteorological data, it became possible to greatly extend the scope of Tornado investigations. To the combination of the older descriptions of single Tornadoes and the newer methods, for they can hardly be separated, the name used for the heading of this section has come into use. There had been numerous reports of Tornadoes in the publications of the Signal Service, ranging from a bare mention in the "Monthly Weather Review" to almost exhaustive descriptions contained chiefly in

the "Annual Reports;" the best example of these last, however is Finley's "Sig. Serv. Professional Paper IV;" but it was not until the publication of Finley's Catalogue of 600 Tornadoes, "Sig. Serv. Prof. Paper VI," that anything like a just conception of the distribution of, or the vast material accumulated concerning, these phenomena was presented to the public.

In this catalogue, up to 1870, are given about double the number of tornadoes found in Reye's table; the remaining 550 (roughly) occurring in the eight years 1874–1881 inclusive. In addition to the classified headings, under which to place observations, as given by Reye, Finley gives the following: Temperature following the storm; (greater attention to) Direction of destructive winds; Time of rain and hail with relation to tornado; Electricity. As might be expected, the records of such a great number of tornadoes allows a more exact statement of their characteristics to be made, but in looking over the results obtained by Finley (for which, and for the excellent suggestions of that writer concerning rules for investigating tornadoes, the reader is referred to the original paper) one is surprised that so few really new features are added to those already stated by Reye. This remark refers to the Tornadoes taken singly. Collectively, the increased number of observations allows such an investigation to be made of Tornado distribution as could not possibly have been undertaken formerly. Finley's charts showing the distribution of tornadoes over the United States are very instructive, but as they are arranged with regard to number, with widely differing periods of time for the different regions, the use of the chart for scientific study is greatly curtailed. Moreover, comparable ratios cannot be obtained by simply dividing the number of observed tornadoes by the number of years during which observations are recorded, because the number of years is merely the difference between the dates first recorded and the last, of Tornadoes given in the accompanying list.

With the preparation of the tri-daily synoptic charts of the Signal Service came the opportunity for a study of the tornadic conditions as related to surrounding atmospheric influences, and

although some of the earlier tornado reports show evidence of their study in connection with these weather maps, yet it was not until Finley entered upon his studies of Tornadoes with such commendable energy and industry that systematic work of this kind was *published.* (The writer is unable to say what attention was paid to this matter by the Prediction Officers during the first eight years of the Signal Service work, as almost nothing has been published concerning their methods or any relations that they may have remarked as existing between the various phenomena that came under their notice. Whether the tornadoes were separated from other violent wind storms, and their locations with regard to the other features of the map were distinctly recognized, is a point on which many meteorolgists would gladly hear from some of those who were engaged in this work.)

There can be no doubt but that Finley's Signal Service Prof. Paper IV (1881) is the most complete record we have of single phenomenon of this kind; embracing as it does, a minute description of a tornado group, containing no less than thirteen individuals, which occurred within a limited area on two successive days; tri-daily weather maps for several days at the time of the occurrence; and numerous diagrams showing paths of destruction and other features of the individual tornadoes. It may be that that writer gave too much space in his report to unimportant details from a scientific point of view, but even these are of practical value for many persons. The value of property destroyed is of no assistance in the study of this question, but it has economic importance which has been very largely increased by the recent formation of Tornado insurance companies. And just here let us consider a question that has recently been raised concerning the question of the frequency of occurrence of tornadoes.

Professor Hinrichs, Director of the Iowa Weather Service, one of the foremost of American meteorologists, and a man who has been recognized abroad for many years as being an exceptionally clear thinker on the subject of storms, has recently disclaimed for the State of Iowa many of the tornadoes included in the Signal Service lists.

Also Professor Lovewell, of the Kansas Weather Service, makes the statement that during the years 1887 and 1888 only one true Tornado occurred in the state of Kansas, (notwithstanding reports to the contrary). This is a difficult and also somewhat delicate matter to remark on, and the following are suggested solely with the view of trying to reconcile the different results obtained by competent investigators. There is no doubt but that the Tornado material accumulated at the Signal Office is carefully and skilfully tabulated; but the question can naturally arise, is a proper weight attached to the observations and remarks of the tornado reporters. Even with a list of points to be noted before him, it is not every person who can make an accurate statement of the characteristics of a common phenomenon. It requires a certain amount of special training before one can observe accurately. Most of the Tornadoes recorded have occurred in rural districts where scientific training has been neglected (this is especially true of the tornado districts of the south), and it can hardly be expected that the exaggeration to which the untrained, or partially trained, minds are inclined, will not be felt in reports of devastating storms. It probably seldom happens that the same tornado reporter is an eye-witness of a number of storms which could be included under the head of tornadoes, and if a storm of unusual character does occur he is ready to discover in it the features to which his attention has been called, and may unconsciously magnify in importance minor points.

That so many of the Tornadoes reported to the Signal Service have the distinctive funnel-shaped cloud, leads one to think that many incipient Tornadoes are formed which do not mature, or at least do not extend to the ground. These phenomena are noticed by the special reporters for the S. S., but as they do no special damage they do not come to the notice of the observers for the State Weather Services, and therefore no record of any Tornado is made by them. Another reason for the great number of Tornadoes reported is, that all spout phenomena are recorded under this head. Now, these water and dust spouts are as likely to occur in other countries as in the United States, and are not

the distinctive "American Tornado" and should not be classed as such; for, they are usually of short duration, and, as they have narrow paths, the danger is relatively slight unless a collection of houses lies in the way.

Dr. Hinrichs, in his recent valuable papers on this subject, has shown that the devastation caused by severe straight blows (Squall. Bö.) called by him Derechos, is frequently assigned to Tornadoes; the fact being that either kind of storm possesses power enough to overturn trees and destroy buildings, and to any but an *experienced* observer there might seem no difference in the effects of the two classes of storms. Dr. Hinrichs' paper is certainly a real contribution to our knowledge of American storms, and the criticisms therein given are to be taken in a scientific spirit. We are still far from understanding, with *certainty*, the tornadic phenomena, and it is evident that the question has not yet been narrowed down to the limits to which it may be confined, to the exclusion of analogous but, as is being shown from time to time, distinct phenomena. The coöperation of the State Weather Services will undoubtedly be of great service in this necessary work of securing greater accuracy in reports of Tornadoes.

To resume the topic departed from in order to make the above remarks, attention is called to Finley's "Tornado Studies for 1884," Sig. Ser. Prof. Paper XVI. This paper is an admirable résumé of the Tornado Reports for that year—giving the characteristics of each Tornado and, what is very important, the sources of information in each case; also, the tri-daily Signal Service weather maps (and meteorological data) are given for important dates, as well as charts showing the location of the Tornadoes with regard to the centers and tracks of areas of low barometric pressure. Finley arrives at several interesting conclusions concerning these relations: 1. Dangerous portion of an area of low pressure (see discussion in back numbers of this JOURNAL concerning the location of this in the SE. quadrant); 2, 3. Tornadoes lie S. and E. of regions of high contrasts of temperature and dew-point; 6. Barometric troughs lying N. and S. or NE. and SW. are more likely to be accompanied by Tornadoes than those lying E. and W.

Unfortunately the late restrictions placed on the Signal Service publications has not permitted the official publication of Finley's recent work, and we only refer to his more popular work, mentioned in a somewhat recent number of this JOURNAL, as well as to the lists he is at present publishing for the different States.

There is plenty of data furnished the student in the papers mentioned, for the study of many points not yet fully considered—for instance, the retardation of the time of greatest frequency of Tornadoes with the increase in latitude (due perhaps to the lower [in latitude] paths of cyclonic areas in the late winter and early spring months than in the summer and fall); the relation between eastward, apparently nearly equal progressive velocities of Thunderstorms and Tornadoes, and the comparison of these velocities with those of the accompanying cyclonic areas, etc., etc.

In considering what improvements may be made in the methods of procedure in investigating not only Tornadoes, but storms in general, especial attention is called to Professor Köppen's papers (also recently mentioned by Professor Hinrichs) in the Annalen der Hydrographie, 1879, p. 324–335 (also Öester. Zeit. f. Meteor., 1879, p. 457, *et. seq.*) "Beitrag zur Kentniss der Böen und Gewitterstürme," and "der Gewittersturm vom Aug. 9, 1881" in the Annal. d. Hydrog., 1883, pages 395–619, 714–737. Professor Köppen spent much time in the preparation of that paper with the intention of supplying a pattern for other investigations, and it would be highly valuable if some one would publish in translation a tolerably full outline of the methods set forth in it.

There is no doubt but that much light will be thrown on the Tornado question by the accumulation of the steadily increasing thunder-squall data, and its thorough discussion in the lines adopted by von Bezold, Ferrari, Prohaska and others in Europe, and by Hazen, Davis and others in America. There have been so many analagous results obtained for these two phenomena, that it is not unlikely that still other points of similarity will be found. For instance, Prohaska's results showing the agreement between the daily periods of thunder-storm velocity and the wind velocity on neighboring mountain peaks, is a very im-

portant matter which should be also sought for as regards Tornadoes and upper air currents.

### III. *Old Tornado Theories.*

The Tornado has long been considered as being but a member of the family of spouts, and in speaking of its theory it is impossible to strictly limit oneself to the special topic under consideration; for various ideas in this connection have a common application, and it would be very misleading to convey the impression that they are to be used only in connection with the investigation of American tornadic phenomena, for this latter owes its differentiation from others of its species, found in other lands, chiefly to its greater extent and mightier power.

It will be sufficient to simply refer to the older theories in order to have more space, in these narrow limits, for the later theories. Schmid, in his "Lehrbuch der Meteorologie" (Leipzig 1860), devotes little space to Tornadoes, but says, they form an intermediate condition (übergang) between the cyclone and the spout phenomena; and still belong to the most mysterious phenomena, as is the case with all of those in which electricity plays an important part. Reye, however, in a few words sums up the different views concerning spouts thus: "Do they originate, as for instance, de Maistre, Redfield, and Oersted think, through the meeting of opposing wind-gusts, so that the turning motion is the primary phenomenon, its suction on the contrary being secondary? Or shall we, with Brisson, Peltier, Becquerel and Hare, consider them effects of statical electricity, which produces, between its carriers,the clouds and the earth's surface, at first a vertical air-current, which revolves later? No further reference will be made to the electrical theories, but it may be remarked that they are still sometimes advocated by two classes of investigators: First, those who would refer the unexplained actions of Tornadoes to some mysterious force; such as they consider electricity to be; and yet they offer no explanation of how this force acts; second, those who have sought to supply the laws of electricity, and have actually experimented with the hope of reproducing on a small scale, the main

features of Tornadoes, and they have been so far successful that the spiral motion has been obtained; and it is by no means certain that the future electricians will not contribute to our knowledge of Tornadoes. Or is, perhaps, Espy right, who explains them as simply ascending air-currents which owe their energy to the vapor force carried along, and vapor condensation? Or, shall we follow the seldom considered teachings of Belt, according to which the lower air layers become heated, from the sun-warmed earth outward, until they are lighter than the upper, and force a way upward in violent whirls?"

## IV. *Modern Tornado Theories.*

If it has been found difficult to separate observed tornadic phenomena from those of other storms, the more recent work of building up satisfactory theories has been still more so. Not only has it been necessary to apply already known principles of mechanics and physics to the explanations of the observed phenomena, but also to institute new researches, both experimental and theoretical, and these, too, of an unusually complicated nature. In the older writings and discussions the method of work in most cases seems to have been to try to fit the observed phenomena to some definitely defined theory, and in order to accomplish this, considerable ingenuity was required in order to make the reasoning plausible, and in many cases suppositions were advanced that were not capable of proof, or that were in their turn founded on principles that were mere hypotheses.

In the newer theories, on the contrary, the attempt is made to explain the observed phenomena by means of those principles of physics and mechanics that are capable of mathematical proof. Of course in these applications of these principles the investigators may not always be in the right, but it is a great gain to know that the foundation is something more than guess work. That the whole question is gradually nearing a final solution is shown by the fact that less and less differences are found in the present theories, and in fact those that are at present acknowledged as possible can hardly be called other than phases of the same theory.

In looking over the papers containing the *modern theories* the attempt to establish priority of ideas is, at first, found to be difficult, and this is especially the case in regard to Reye and Ferrel, and it requires something more than the dates of publications of their papers to show which was the first to make a beginning in what is now considered the true explanation. When a finished book, such as "Wirbelstürme," appears, we know that years have been spent in accumulating material and the special knowledge necessary for its production; and although the date is February, 1872, yet we find that many of Reye's original contributions contained in it are based on a very important paper published by him in 1864 in Schlömilch's *Zeitschrift für Mathematik u. Physik*, and titled, "Ueber verticale Luftströme in der Atmosphäre." And, in turn, this paper shows strong evidence of at least some years' reading and thought in this direction. On the other hand Ferrel's early paper was written in 1858, and we know that he commenced the consideration of the subject sometime before that, for his paper of October, 1856, shows that even then he had in mind the bold theory stated three years later. We think the question of precedence is definitely settled, however, by some data in regard to Reye's life, viz: born 1838, graduated at Göttingen, 1861. (See Hellmann's Repertorium der Deutschen Meteorologie). That is, Reye was 18 years of age, and had not yet entered the University when Ferrel's first paper was published. Another point we must not overlook is that at first Reye gave his attention to the investigation of the *initial cause* of interchanging vertical air currents, while Ferrel, almost assuming the interchange had commenced, confines his analysis to the resulting motions and their effects. So that both of these investigators were in reality working out distinct parts of the same problem. In the earlier part of his work Ferrel seems to have been unaware of Reye's work, while even in Reye's later work we find no mention of Ferrel's contributions.

*Reye's Theory.*—In a chapter on the "Ursachen und Entstehung der Wettersäulen," Reye gives his views as to the origin and sustaining power of the whole class of spout-phenomena.

He says: "We think, with Muncke,* Belt† and Espy, that the 'wetter-säulen' are vertical air currents which carry up, in whirls, the warm, moist air from the earth's surface, or bring down the cold air from above. But we do not agree completely with the just mentioned savants as to the manner and means by which these air whirls are produced." Taking into account the analogy between these and columns of smoke and fire, and the fact that they occur suddenly in calms, with a sultry atmosphere, and in such places as the air has become super-heated, he thinks they are preceded by an unstable equilibrium of the air and that this causes the powerful changes of the layers of air by which stable equilibrium is restored. The origin of this unstable equilibrium is due to the heating up of the earth and air layers, but it is impossible to state with absolute certainty the process in each case, as it may be accomplished in a variety of ways. In this connection the question "with what temperature relations is quiet air in unstable equilibrium?" is of the greatest importance. Reye found that in order to produce unstable equilibrium (*i. e.*, to render the lower layers of air specifically lighter than any above) the decrease of temperature with elevation must be more than 3.42° Centigrade per 100 meters, (see previously mentioned paper of 1864, and also appendix No. 3 of Wirbelsturme); this, however, has seldom been observed directly, and he concludes that some modification of the ideal case is necessary for explaining the great secret of spouts.‡ He remarks that in actual fact the indifferent equilibrium can occur by a much less warming up of the lower layers than is necessary for rendering them specifically lighter than he upper layers; and then goes on to prove that a mass of air if slightly disturbed, may have an indifferent or oscillating equilibrium, such as a balloon partially immersed in

* Gehler's Physikalischem Worterbuch.

† Philosophical Magazine, 1859.

‡ We have almost no observed data concerning the decrease of temperature with elevation at the time and place of occurrence of spouts, and this theoretical decrease may occur in nature oftener than we suspect. Here, again, thunderstorm studies will be of great aid in settling this question; for there is some recorded data, showing the approximate vertical decrease of temperature during or preceding these storms.

water would have if disturbed by a slight pressure. If, then, a quantity of air is forced upwards, it of course expands and cools; and if this change (according to Poisson's law of tension) of temperature is greater than that of the surrounding air, then the air that was moved upward must fall again to its old position. The equilibrium is then *stable* or *steady*. But if the ascending air cools slower than the surrounding air then instead of descending it will go up still higher, and in this case the equilibrium will be unstable or oscillating. Reye's computations show that the air remains in its new position, in *indifferent* equilibrium, when the temperature decrease is 0°. 993 Centigrade, per 100 meters. But this unstable state of the atmosphere can lead to downward as well as upward currents; the preponderance of the former being due to the presence of water vapor. We cannot reproduce what Reye says in regard to this, but he leads to the fact that "moist air rises much easier in the air than dry air." In fact, the upward motion can occur with moist air when the temperature decrease is only $\frac{1}{3}$° Centigrade per 100 meters, and furthermore, "moist ascending currents occur much easier in the higher than in the lower layers of the atmosphere." So we find the spout conditions are more easily formed at distance above the earth's surface. Summing all up, Reye says: "we find that spouts (wettersäulen) are produced by warm vertical air currents."

*Ferrel's Theory.*—In his first paper, of 1856, (see reprint in Professional Paper XII, Sig. Ser.) Professor Ferrel seems to have accepted Espy's view as to the initial cause of Tornadoes and similar storms, but it is here that we first find his ideas of gyratory motion applied to these phenomena. In his next paper of 1858-9, in the Cambridge (U. S.) *Mathematical Monthly* (reprinted as Sig. Ser. Prof. Paper VII, Part I, 1882), Ferrel seems to consider Epsy's theory as only in part accounting for the cause and maintenance of the Tornadoes. See §§ 58, 66. In this latter section he says: "Tornadoes generally occur when the surface of the earth is very warm and the atmosphere calm. For then the strata near the surface become very much rarified, and are consequently in a kind of unstable equilibrium for a while,

when from some slight cause, the rarified atmosphere rushes up at some point through the strata above, and consequently flows in rapidly from all sides below, and then, unless the sum of all the initial moments of gyration around the center is exactly equal to 0, which can rarely ever be the case, it must run into gyrations near the center, and a Tornado is the consequence.'' In this paper there is given also a satisfactory explanation of the formation of the funnel-shaped cloud as observed both in Water and Sand Spouts and Tornadoes, also of the cause of the explosive-like forces so frequently observed in Tornadoes. This paper of Ferrel's is so condensed, however, on account of the small amount of space at his disposal in the Journal where it first appeared, that it does not show how far he had developed at this time the theories elaborated in his later paper, Meteorological Researches, Part II, Washington, 1880. In this latter paper he has published for the first time a detailed investigation of the principles on which he regards the subject of Tornadoes to be founded. Considering them as "simply special cases of cyclones," he has so modified his analysis of these latter as to make it applicable to the former; and, too, he recognizes Reye's important contributions. The result is, that we meet here, for the first time, a judicious combination of the earlier dynamical theory of Ferrel and the physical theory of Reye. This paper was the subject of a most interestimg "review" by Sprung, in "Öster. Zeit. für Meteor. 1882;" and Ferrel also published a popular exposition of it, in the *American Journal of Science*, July, 1881.

The latest and most complete paper on Tornadoes, by Ferrel, is his treatment of this topic in his "Recent Advances in Meteorology" (Washington, 1885). Any one reading the account he has given there can not but be struck with the clear, and what might be termed common sense, views expressed therein; and he has included in his remarks the later results of the Signal Service "Tornado Studies." We cannot reproduce here a connected summary of Ferrel's Mathematical Analysis, as it would necessitate reviewing his theory of Cyclones also, so the best that can be done is to strongly urge the reader to make a careful study of the original.

The application to Tornadoes of his dynamics of Cyclones required much modification as regards friction and the effect of the deflective force of the earth's rotation. The initial state of the Tornado depends simply on the condition of unstable equilibrium for saturated air at the existing temperature; and in this respect also, the reasoning is different from that applied to cyclones.

We think it not out of place to mention, just here, that Professor Ferrel is about to publish a most interesting popular statement of his views on Tornadoes.

*Guldberg and Mohn.*—Almost simultaneous with Ferrel's "Meteorological Researches" (Part I, 1877; Part II, 1880), there appeared Guldberg and Mohn's "Etudes sur les Mouvements de l'Atmosphère" (Part I, 1876; Part II, 1880), and these latter are of the highest importance in connection with the study of the action of Tornadoes. In Part I of the "Etudes," the authors treat of the expansion and contraction of air due to changes of temperature and pressure, and taking into account the humidity; the forces acting on both horizontal and vertical currents of air; the horizontal currents caused by a vertical circulation; the causes of vertical currents; and the analysis of cyclonic winds, of both large and small whirls. The present writer wishes, however, to call attention to the fact that Professors Guldberg and Mohn have considerably modified their analysis of the "conditions for the existence of ascending and descending currents of air," page 35 (Part I), being entirely replaced by a manuscript furnished in the copy by the authors for the translation made for the Signal Service some years ago.

In Part II of the "Etudes" we find still more matter having a direct bearing on the Tornado question, such questions as the following being discussed mathematically: vertical gradients; conditions of continuity; interior friction in revolving currents of air; systems of "parralléles ascendant" and "parallelés descendant" (that is, systems having two horizontal currents, the one along the surface of the earth and the other in the upper strata, the two being connected by a vertical current); instantaneous systems of wind; movable systems of wind; velocity of

propagation of a cyclone; action of the rotation of the earth on vertical currents. In this paper we find no such special treatment of Tornadoes as Ferrel has given, but there is given the analysis of the various points necessary for the construction of a connected treatment of the subject. The authors have not carried out this work, however, because they considered that not enough reliable meteorological information has been obtained for them to show the changes of pressure and velocity that take place. It will be noticed that even in Ferrel's work such points as the actual barometric pressure and wind velocities within Tornadoes are either assumed, or obtained in such a roundabout way as to be very uncertain.

Guldberg and Mohn's papers in the "Oester. Zeit. f. Meteor., 1878," on "Temperature Changes in the Vertical Direction in the Atmosphere" and "Vertical Air Currents" are also very important to the student of our topic.

Professor Mohn's general ideas in regard to Tornadoes can be given in a few words. They are formed by ascending air currents which are having their vapor of water constantly condensed up above. They are violent *secondary* whirlwinds which are formed on the warmer southern side of the primary cyclones. Spouts, *and partly at least also Tornadoes*, originate when the air is in a state of unstable equilibrium, etc. (See Mohn's "Grundzüge der Meteorologie," 1883).

For a connected development of modern theories of Tornadoes, Davis's "Whirlwind Cyclones and Tornadoes" (Science Series, 1884), and Sprung's "Lehrbuch der Meteorologie," (1885), are to be particularly recommended. The former, popular in style and historical in comprehensiveness, is adapted for general reading; while the latter, written for the special student of meteorology, is the best critical compilation of modern theories, including the mathematical analysis, that has appeared. Sprung's treatise, although professedly a compilation, is, in reality, an original contribution to the knowledge of the subject. He has not only remodeled many of the mathematical expressions in order to make them enter connectedly into the mathematical development of atmospheric mechanics as given in his treatise,

but he has also discussed the applicability of investigations of a number of special physical and meteorological topics to the Tornado question. There have, from time to time, been experiments carried on for the purpose of studying artificially produced atmospheric whirls, and Sprung makes special mention of Vettin's work in this line. We find that, while Ferrel's views are largely quoted by Sprung, which is particularly gratifying to us as Americans, the theories of Faye and others who insist on there being a descending current in the interior of a Tornado are combated as not being supported by the results of computations and observations, either given or referred to by the author of the "Lehrbuch."

There has been much discussion concerning Tornadoes, during recent years, in some of the Science Journals, and for these, the volumes of the "Comptes Rendus," "Meteor. Zeits.," "Öster. Zeits. f. Meteor.," "Science," and THE AMERICAN METEOROLOGICAL JOURNAL, must be examined.

There is a class of investigations that may be termed Accessory Problems, that are of the greatest importance in explaining Tornado action, We mean such questions as "Vortex Motion," "Condition of Continuity," Application of "Mechanical Theory of Heat," etc., (many of which are treated by Guldberg and Mohn). It was intended to make particular mention of these, but space cannot be allowed.

## THE WHIRLPOOL THEORY OF STORMS.

BY M. W. HARRINGTON.

M. Faye is an eminent astronomer, a member of the Institute of France, a former assistant of Arago, and a member of the Bureau of Longitudes. Some fifteen or twenty years ago he was led by a study of sun-spots to formulate a gyratory or whirlpool theory of storms, and this theory he has persistently supported, by word and pen, from that time to this. It has been repeatedly stated and argued for in the valuable *Annuaire* of the Bureau of Longitudes, and has been more recently formu-

lated in a small book entitled *Sur les tempêtes* (1887). It is from these sources and from various criticisms with his replies to them, which Mr. Faye was kind enough to send me, that I draw up an abstract of this theory for the benefit of the readers of the JOURNAL.

While Nature has boundless variety, she often employs the same means for effecting very different purposes. Under certain conditions she employs whirlpools in water, especially in running water; it is highly probable that she would employ similar whirls in gaseous fluids, especially in such fluids in motion. Now the form and characteristics of the whirlpool in water are very familiar and very characteristic, and if we look through the series of aerial phenomena we find one entire class that reminds us at once strongly of the whirlpool, and that is the class represented by the tornado and waterspout. The funnel of the tornado is of the same form as that of the whirlpool: it has the same mobility or changeability, and at the same time the same persistence; and, moreover, just as the energy of the whirlpool is surprisingly great at its apex, the energy of the air at the apex or point of its funnel is unfortunately very great. This suggests at once the basis of M. Faye's theory, and it can be formulated about as follows: All vortical storms (the tornado, waterspout, typhoon, hurricane, cyclone), are descending aerial whirls with a vertical axis, having their origin in the upper air currents, and from them their energy is drawn. In other words, vortical storms are aerial conical whirlpools with mouth at the level of the anti-trades and apex directed downwards.

The theory is a simple one, easy to comprehend, and one for which we can find familiar analogies. Just as threads of water adjacent to each other and of dissimilar velocities will cause a whirling motion resulting in the familiar whirlpool, so will two adjacent streams of air of unequal velocities cause an aerial whirl, and this whirl will be propagated downwards just as the aqueous whirl is propagated downwards. The remarkable energy at the apex of the whirlpool is easily accounted for by known mechanical principles, and in an exactly similar way the destructive effects of the tip of the tornado funnel may be ac-

counted for. Moreover, the great velocities of the upper air currents give an abundant store of energy to draw from, the high electric tension between the upper air and the earth will easily account for the electric phenomena and their low temperature for the cold of hailstorms.

The theory has another striking advantage over the earlier ones; it finds no difficulty in what has proved heretofore hard to explain, and that is the progressive motion of cyclones. Whirlpools caused by obstructions in a stream remain nearly fixed in position; those, however, which are caused by varying currents travel with those currents. The latter are those similar to the aerial whirls and these are similarly carried with the air currents which produce them. The upper currents are westerly near the equator, but in low latitudes they turn, and in all temperate regions they travel in a southeasterly direction; hence, while tropical cyclones travel westward at first, they soon turn northeastward, and, with all which originate in temperate regions, they hold this direction thereafter.

As to the aerial origin of such storms, M. Faye cites in proof of it the well known fact that the tornado funnel and waterspout extend downwards from above. Indeed, it often happens that tornado funnels are seen which fail to extend as far down as to the surface of the earth, and in these cases the destructive effects of the storm are not experienced.

Such storms are then aerial whirls, with circular, nearly horizontal winds, in which, however, there is, as in the whirlpools, a slightly descending component in the velocity of each air particle. This theory presents many disagreements with current theories, and some with accepted facts; I will now endeavor to show how its author disposes of these. In the first place he contends that all the vortical or cylonic phenomena are phenomena of the same sort, differing only in size and in unessential particulars. The tornado and waterspout are complete aerial whirls. The small dust whirlwinds and the little local summer whirls are presumably members of the same brotherhood originating in local conditions. The hailstorm and thunderstorm are whirlpools which reach as high as the upper cirrus from

which they derive their electric phenomena and the low temperature necessary to make hailstones. The general cyclone and the hurricane and typhoon are large whirlpools for which the lower atmosphere is too shallow, so that we have only the upper part of the whirlpool. Moreover, the temperature of the descending air depends on the presence or absence of moisture. Originally very cold, it warms up by compression as it descends, and if the air below is dry, it retains this heat and is felt at the earth's surface as a hot wind, such as the sirocco and the simoom. Even the foehn is but a dry secondary whirl caused by topography, and in the midst of a moist larger whirl.

These whirls being pure gyrations must be, under M. Faye's theory, nearly or quite circular, hence the gentleman adheres to the circular winds of the early storm laws, the winds as taught by Redfield, Reid, and Piddington. He does not believe in the centripetal winds as taught in the views generally accepted. The storm cards used by navigators, it seems, represent the winds as circular, just as Piddington's storm card gives them. Now the maneuvers of a vessel in a cyclone with circular winds will be different from those in a cyclone with centripetal winds. What would give safety in one case might prove highly dangerous or destructive in the other. Vessels have been successfully brought out of cyclones on maneuvers for circular winds, and seamen generally believe in circular winds. M. Faye thinks that the circular character of the winds is most marked and best illustrated in tropical storms. In the temperate regions the circular path is apparently somewhat broken up and cannot be so easily detected. To the statements of some students of tropical storms that the inclination of the winds to the isobars is especially great in the tropics he retorts the equally authentic statement of Mohn in his Meteorology, that the path of the winds in tropical cyclones is circular. The "eye of the storm" he views as especially in favor of his theory.

To the objection that his theory makes the air descend in cyclones while many observations show that it ascends, he replies that no authoritative observations have been as yet made on the

subject. The ordinary statement that bodies are seen to ascend in the tornado funnel and water to ascend in waterspouts he considers illusions. These storms do not pump water and the ascent of light bodies is outside of, not in, the funnel. The whirlpool carries the water down to the apex of its cone; small floating bodies which descend with it are thrown ont of the vortex below and rise outside of it. In the same way as the water is thrown out on each side of the apex of the whirlpool and does its work on the bottom of the stream when the whirl extends so far, the whirl of air in the tornado is thrown out with enormous velocity at the bottom and does its destructive work on objects in its way. It then rises tumultuously around the funnel and as it does so may carry ojects up with it to a greater or less height. M. Faye goes on to point out that smoke sinks in a cyclone and that no mariner has ever seen his pennant pointing upwards when the current meteorological theory requires an ascending current. The existence of these currents of aspiration are, according to him, purely theoretical; they have not yet been authenticated by observation.

To the objection that the low barometer in the center of a cyclone indicates a current of aspiration, he objects that this low barometer is a dynamical phenomenon, explainable by other aerial motions than ascending ones. I have not found his arguments in detail on this point, but I am stating the impression left on my mind by what he does say, by saying that a depression of the barometer might be the result of horizontal motion, especially if this motion is circular.

What precedes indicates the main objections to his theory and the character of his replies to them. I have refrained from the polemics of the controversy and have endeavored only to give a correct idea of M. Faye's theory and his defense of it. In the course of his defense he frequently criticises severely the meteorological theories which meet with general acceptance. To show that the current theories are untenable is, of course, an argument which tends to strengthen his own theory. The full strength of his theory could not be made out without giving his criticisms on the other theories. This, however, I will give in a

translation of his own words, in the form of a series of problems which he propounds, at the end of his book *Sur les tempêtes*, for the meteorologists who differ from him. They are as follows:

ON TORNADOES AND WATERSPOUTS.

1. Does their figure of revolution around a vertical axis indicate anything but a gyratory motion? Is there a chance for an influx of exterior air toward this vertical axis?

2. To find, in examining the violent action exercised on the soil, any trace whatever of such a centripetal motion of the air toward the inferior orifice?

3. Why do tornadoes travel? Why should there be no gyration without the translation along a perfectly definite path?

4. Why this translation in the midst of a calm atmosphere?

5. Why this translation even when the wind blows without any other effect than a slight swaying of the lower end of the funnel?

6. Why do we see tornadoes and waterspouts form above and descend until they reach the earth's surface?

7. How is it that they can pass above our heads without reaching the surface or doing the least damage?

8. Why do they retract and disappear in the clouds instead of contracting and withdrawing little by little to the surface?

9. How is it that a tornado can do the work necessary to demolish a building in an instant or throw down thousands of trees and make a passage through a forest without that this enormous expenditure of energy should cause any change in its pace?

STORMS.

10. Why do storms advance? Why do they advance for several weeks without being disorganized or weakened by any obstacle?

11. Why is their path, like their gyration, controlled in each hemisphere by the diurnal rotation of the globe?

12. Why is their progress such that they can cross the Atlantic from America to Europe, but never from Europe to America?

13. Why does the storm which traveled west and north in

the tropics, travel north and east in the temperate regions?

14. The form of storms, at their beginning in the tropics, is identically that of tornadoes; to find, in these simple cases, any trace whatever of a centripetal motion of the air?

15. Why is there a calm area in the center of each storm?

16. Why does the storm cease suddenly at the border of this calm area?

17. Why is the calm area alone clear?

18. Why is the air in the calm area warmer and drier than in the tempest, and why is the change in this respect as sharp as for motion?

19. Is the barometric depression which accompanies a storm a sign of local rarefaction or a fact dependent on the mode of transmission of pressure in a medium which is traversed above by vast and rapid gyrations?

ACCESSORY PHENOMENA.

20. To explain the phenomena of the segmentation of one gyration into a series of partial gyrations following about the same path?

21. Why are hailstorms and tornadoes simply secondary phenomena attached momentarily to the right flank of a cyclone?

22. Why are their paths constantly parallel to that of the cyclone?

## CORRESPONDENCE.

### CYCLONIC WINDS OVER A FIRE.

TO THE EDITORS:—I enclose a slip cut from a California paper on the "Waltzing Giants of Nevada," for which I do not propose to be held accountable. I will narrate a little phenomenon that occurred near here a short time since, for the truth of which I can vouch:

My neighbor, J. H. Brinton, having a small patch of barren land underlaid with serpentine, containing, say, three or four acres, determined to burn off the old crop of dry sedge grass that grew upon it. So, waiting for a still day, which soon came

to suit him, he then with several men quickly set fire to the grass on the circumference of the plot, and thus had a very complete circle of fire. This quickly made a draft on every side toward the centre, which soon ran over the plot, making a pretty dense smoke. This smoke took the funnel shape of a tornado cloud, rising to a considerable height, and having the customary rotary motion from left to right. The lifting force did not develop much power, but it showed very clearly how, with sufficient material and the atmosphere in a favorable condition, a tornado could be made to order. A. SHARPLESS.

WEST CHESTER, PENN., May 28th, 1889.

[Mr. Sharpless's clipping relates to the sand whirls of Nevada and is so entertaining that only lack of space prevents its insertion. The writer of the clipping insists so far on the lifting power of the whirls that he makes it take up a man, a mule, and a prospecting outfit. The writer has frequently watched them in New Mexico, and doubts if they have any lifting power worth mentioning.

Mr. Sharpless's own story relates to a phenomenon which is not so common but that it deserves record. It reminds one of the frequently quoted account of Mackay, given on page 32 *et seq.* of Espy's Fourth Meteorological Report.—H.]

## THE MEASUREMENT OF WIND VELOCITY.

TO THE EDITORS.—I should like to make a few remarks upon the articles on wind measurement which have recently appeared in your JOURNAL.

The English experiments to which allusion has been made were undertaken with the primary purpose of determining the constants of the Kew pattern anemometer, rather than with the idea of making any general study of the question, and the report made to the Royal Meteorological Society in May, 1888, is only a preliminary report.

In the report it is stated that no correction has been applied for the natural wind, and also that the factor appeared to be fairly constant for velocities above 15 miles per hour, but it is not stated that the factor is constant for all velocities.

I am well aware of the necessity of the correction for the natural wind, even though no low speed experiments were made, and stated in the discussion on the report that I did not consider that the factor could be satisfactorily deduced from the observations until that correction was applied.

The difficulties, however, are very great, partly because the factor varies with the velocity, and partly because the Robinson anemometer exposed to a variable wind records neither the mean velocity nor the mean square of the velocity, but something between the two, that something depending upon the moment of inertia of the particular instrument.

There is also the difficulty of accurately measuring the wind during the experiment.

It is on account of these difficulties that a further report has not yet been drawn up.

I am very pleased to see that Professor Marvin has called attention to this point about the action of a Robinson anemometer in a variable wind, having for some time been of opinion that the recorded velocities are too high from this cause. I have made some experiments during the past winter which confirm his result.

I cannot agree with Mr. Hazen that the vertical position for the cups is objectionable, having deliberately chosen it for two reasons: firstly, beccause it avoids the difficulty of having to rotate the whirler in opposite directions and the consequent evil of having to choose some mean between two discordant results, which perhaps, with an instrument with long arms, may differ by 30 to 40 per cent; and secondly, because in the horizontal position the strains due to the centrifugal force are more complex, and therefore the change in the friction more uncertain.

The vertical position is not used in practice because the direction of the wind is variable, but there seems to be no good reason why a Robinson anemometer should not act equally well in any position in which the plane of the cups is parallel to the wind. The only possible effect is a very slight alteration in the friction.

The Helicoid Anemometer used was not of the ordinary air meter construction, but is made so as to adjust itself automatic-

ally to any friction. In many of the experiments the instrument was wedged up so that it could not turn at all at low velocities, but as soon as there was wind enough to move it, the increased friction did not alter the result. It is probably due to the self-adjustment of the instrument that the values were so much more consistent.

For low speeds no doubt a closed-in space is the best, but I do not think this to be the case for high velocities. So far as can be judged from the observation of smoke from damp vegetation burnt just under the path of the instrument at Hersham, the *mitwind*, which seems to be so troublesome in experiments, is avoided by working in the open. The natural wind, however, must be allowed for, and this is certainly a great difficulty when its velocity is at all comparable with that of the whirler.

Many meteorologists in this country share in the opinion that the Robinson annemometer cannot be considered a satisfactory instrument, but it certainly possesses two great advantages, its simplicity and its being independent of a wind vane.

W. H. DINES.

ESHER, SURREY, ENGLAND, May 17, 1889.

## CURRENT NOTES.

MCGILL COLLEGE OBSERVATORY.—This observatory, located at Montreal, is under the direction of Professor C. H. McLeod. From the annual report for 1888, we learn that, aside from astronomical duties, it is a principal station of the Canadian weather service. It has carried on a series of bi-hourly meteorological observations since 1884. Professor McLeod also makes regular record of soil temperatures electrically. The method is described by him as follows:

"The apparatus for the observation of the temperatures of the soil at various depths has been in operation since October. The following is a brief description of the method: Couples of copper and iron are placed in the ground at the required depths. A wire passes from each couple to a switch-board in the observing room, and there is a return wire common to all couples,

which, in the observing room, passes through a delicate galvanometer and a couple similar to those in the ground, to make connection with the other wires at the switch-board. The galvanometer is made to read zero on the circle when the circuit is open. If now the circuit be closed at the switch-board the needle will be found to deflect, but may be brought back by bringing the inside couple to the same temperature as that in the ground. For this purpose the inside couple is immersed in water, or in winter, in a mixture of snow and water. When the balance is established, the temperature of the water is the same as that of the ground at the depth of the outside couple. These observations are undertaken in conjunction with Prof. Penhallow, representing the Natural History Society of Montreal, and are of great importance in their bearing on agriculture in Canada."

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SOUTHEASTERN BRITISH COLUMBIA.*—This book describes a three months' ramble through the very interesting region about the headwaters of the Columbia and the Kootenay Valley—a region not very well known, but thought to contain rich mines and valuable agricultural tracts. It is also a region likely soon to be easrly accessible by steamers on its great rivers and numerous lakes, and by a railroad which will connect the two great northern trans-continental lines. It has an interest also for its many deserted mining towns, built by gold washers nearly half a century ago, and because of its harmless Indian population, among which are scattered many Chinese. Latterly the valley of the Kootenay has been represented as having an extraordinarily favorable climate for its latitude, and attention has been drawn to it as a very favorable place for immigration.

All these things make especially interesting the observations of the three jovial hunting, fishing Englishmen (two of whom are the authors of this book) who made a rambling trip from the Canadian to the Northern Pacific railroads. The book is hu-

* B. C. 1887. A Ramble in British Columbia by J. A. Lees and W. J. Clutterbuck, with Map and 75 Illustrations from Sketches and Photographs by the authors. London: Longmans, Green & Co., 1888. Octavo, pages 387.

morous, and much space is devoted to such tales and trivialities as a party of good-natured anglers delight to indulge in; but from it all we can gather a clear picture of the country, its occupants, climate, and possibilities. The Kootenay region is evidently not a paradise: the mosquitoes are very numerous and always hungry, the weather is very variable, the country is so rough that the agricultural lands are quite restricted in area; yet, on the other hand, the mining prospects are good, the climate is mild and is favorable for agriculture and for grazing; wheat lands there are and unusually rich, and there is abundant water and fine timber; moreover the hunter and fisherman will find this region excellent ground for them so long as it remains in its present unsettled condition.

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THE REGISTRATION OF VITAL STATISTICS.—The birth and death record makes but a meagre contribution to the fund of vital statistics, and yet it is a step in the right direction, and we hope there will be a prompt and hearty response to the proposal contained in the following circular. It is to be regretted that we have no permanent organization in this country for collecting information, not fitfully and at long intervals, but continuously, with regard to those influences which affect the welfare of humanity. The resolution which was passed by the Section on Climatology and Demography of the last International Medical Congress called attention to the "necessity for the establishment of a National department, bureau or commission for the record of Vital Statistics upon a uniform basis, to include not only accurate returns of births and deaths, but the results of collective investigations by government officials of facts bearing upon the natural history of disease as manifested among men, women and children separately, especially with regard to climatic and other discoverable causes of the several forms of disease—race, residence and occupation being also made matters of record—that necessary preventive measures may be determined and enforced for the preservation of the public health." The value of a systematic collection of statistics of this nature is apparent to all. Such duties might

be successfully grafted on to our Signal Service, by securing the services of well qualified physicians located in the vicinity of each station. Or our Marine Hospital Service and army and Navy Medical corps might readily be made the avenue through which such information could be obtained without much addiditional expense to the government. Let the subject be agitated and discussed by both national and local sanitary and climatological associations until the desired result is brought about.

W. J. H.

DEPARTMENT OF THE INTERIOR,
CENSUS OFFICE,
WASHINGTON, D. C., May 1, 1889.

*To the Medical Profession:*

The various medical associations and the medical profession will be glad to learn that Dr. John S. Billings, Surgeon U. S. Army, has consented to take charge of the Report on the Mortality and Vital Statistics of the United States as returned by the Eleventh Census.

As the United States has no system of registration of vital statistics, such as is relied upon by other civilized nations for the purpose of ascertaining the actual movement of population, our census affords the only opportunity of obtaining near an approximate estimate of the birth and death rates of much the larger part of the country, which is entirely unprovided with any satisfactory system of State and municipal registration.

In view of this, the Census Office, during the month of May this year, will issue to the medical profession throughout the country "Physician's Registers" for the purpose of obtaining more accurate returns of deaths than it is possible for the enumerators to make. It is earnestly hoped that physicians in every part of the country will co-operate with the Census Office in this important work. The record should be kept from June 1, 1889, to May 31, 1890. Nearly 26,000 of these registration books were filled up and returned to the office in 1880, and nearly all of them used for statistical purposes. It is hoped that double this number will be obtained for the Eleventh Census.

Physicians not receiving Registers can obtain them by sending their names and addresses to the Census Office, and with the Register, an official envelope which requires no stamp will be provided for their return to Washington.

If all medical and surgical practitioners throughout the country will lend their aid, the mortality and vital statistics of the Eleventh Census will be more comprehensive and complete than they have ever been.

Every physician should take a personal pride in having this report as full and accurate as it is possible to make it.

It is hereby promised that all information obtained through this source shall be held strictly confidential.

ROBERT P. PORTER,
Superintendent of Census.

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THE APPROACHING YELLOW FEVER SEASON. — The lesson taught by the yellow fever outbreak in Florida last year has not been unheeded. It has occasioned the organization of what appears, at this distance, to be an efficient State Board of Health in that State and the appointment of a Health Officer who will devote his entire time to the duties of his office. Alabama is alert. Dr. Cochrane, chairman of the State Board of Health of that State, has recently made a tour of inspection through Cuba and southern Florida, and reports that there are but few cases of yellow fever in Havana and none in Florida since the one reported in Sanford two months ago. With its enlarged facilities the Marine Hospital Service are prepared to act even more promptly and efficiently than hitherto. A rigid quarantine is being maintained, so that little is to be feared from the introduction of the contagium from without. If equal vigilance is maintained with reference to all internal sources of propagation the present summer, no matter how favorable the meteorological conditions may be for its development during the next three months, will have no repetition of last year's experiences.

In this connection it will not be amiss to call attention to the careful analysis by Dr. John Guitéras contained in an article entitled "Some Observations on the Natural History of Yellow Fever, etc.," which is to be found in the report of the Marine Hospital Service for 1888.

From his observations the author has reached the conclusion that the opinion which has heretofore prevailed among residents in the "yellow fever belt," that children are exempt from the disease, is erroneous, and that the reason for this error is a mis-

taken diagnosis of the disease, which, in children, does not assume the same character as in adults.

According to Dr. Guitéras, many cases of sickness and death among children during those seasons of the year when yellow fever prevails have, by reason of their preconceived opinion and from the change of symptoms as it appears in them, been regarded as due to malaria or bilious remittent fever, when they have been in reality cases of yellow fever, and, as such, have been the cause of transmitting the disease to others. Many able physicians and sanitarians in the South are in accord with this view, and a knowledge of this fact will go far toward arresting what may have been in the past a fruitful source of contagion.

W. J. H.

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General Weather Conditions.—It is interesting to note an editorial with the above title in so representative a farmer's paper as the *Grange Visitor*. The editor, Mr. A. C. Glidden, is an influential member of that very numerous class, the farmers, which is more interested than any other in inland meteorology, and his views are conservative. He thinks that, while the work of man, as in disforesting, may play a minor and unimportant part in determining weather conditions, they lie for the most part beyond his reach, and have their causes in the higher atmosphere,—or at least in that part of it which lies several hundred feet above our heads. Here lie the causes of drouth and heavy rainfall, and while locally at the surface these tend to self-continuance, the more general causes, lying above us, limit them. As these causes are yet unknown, long-time weather predictions are impossible. Mr. Glidden thinks we had as marked drouths and floods in the earlier history of the country as we have now.

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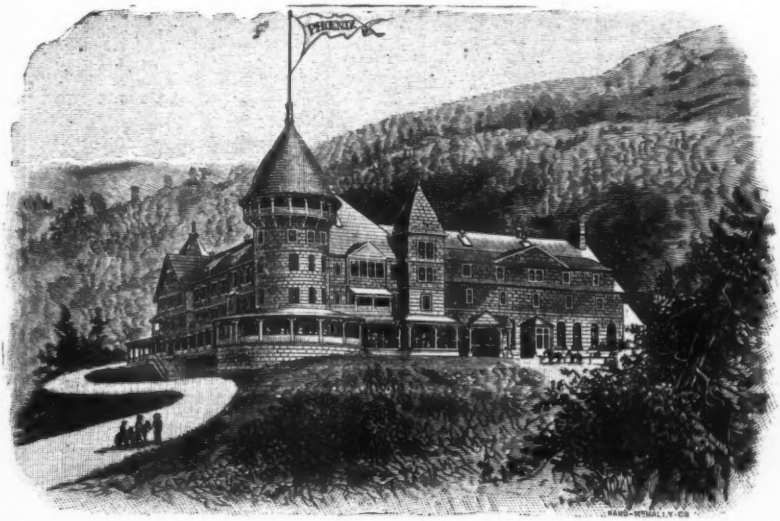


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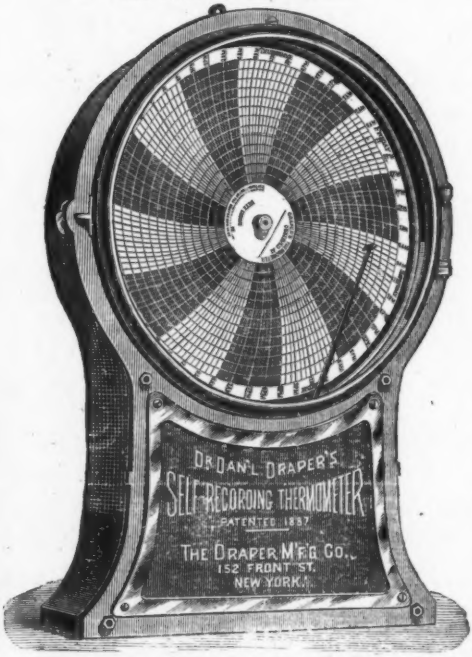


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